Lecture 9

Poles and Zeros

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Outline

- Meaning of Poles and Zeros
- Analysis of R-C Network
- High frequency model of MOS

Why Do We Learn Frequency Response?

- Static (DC) signals often do not provide enough information.
  → e.g. voice, video, (still image?)
  → Information is usually stored in time varying signals.

- An easy way to analyze time varying signals is to look at it in the frequency domain.

Laplace Transform

- Laplace transform is just one of the many methods to analyze linear system.

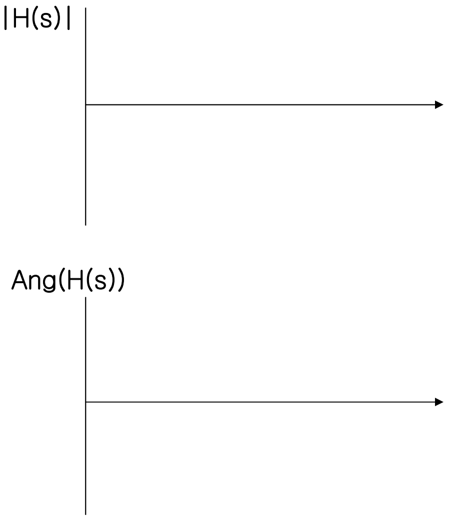
- Why Laplace Transform?
  →Differential equations are transformed into algebraic equations.
  →It provides insight. (many techniques are based on s-domain representation of signals)

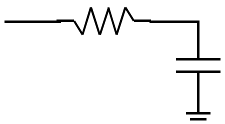
Poles and Zeros

- Mathematical Meaning
  - Pole : $D(s_p) = 0$
  - Zero : $N(s_z) = 0$
- Analytical Meaning
  - Pole
    - Determines the stability of the system
    - System Pole determines the natural/transient response
  - Zero
    - Determines the transient behavior
- Physical Meaning from Circuit Standpoint
  - Pole:
    - A low impedance path to ground. (single-ended)
  - Zero:
    - A short to the input source.
    - A multiple path from source to the output.
    - + α

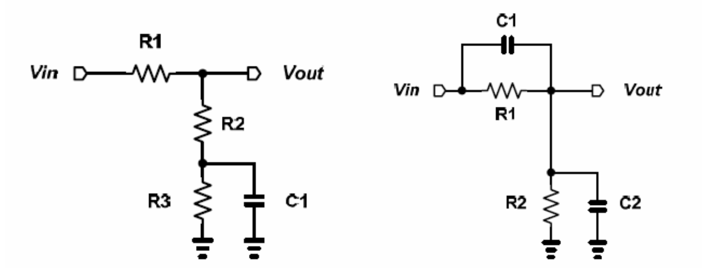
Bode Plot

- Poles:
  @pole ➔ - 3dB
  -20dB/decade
  -pi/4/decade
  - pi/2 total phase shift
- Zeros:
  @zero ➔ +3dB
  +20dB/decade
  +pi/4/decade
  + pi/2 total phase shift

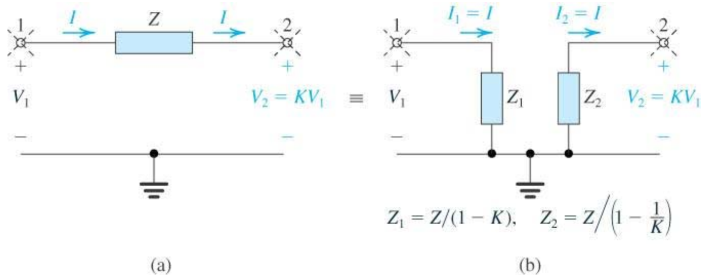




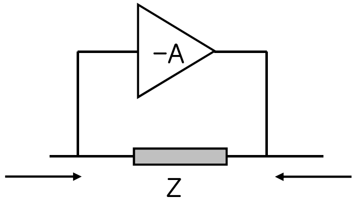
Analyzing System with Poles and Zeros

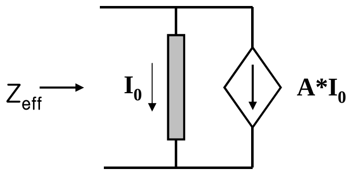


Miller Theorem



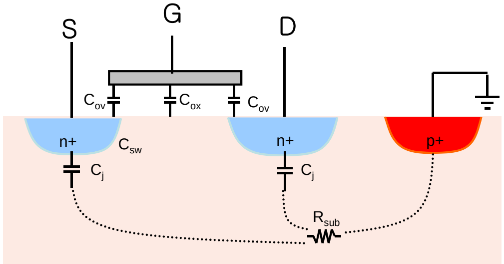
Impedance Multiplication

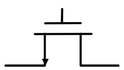




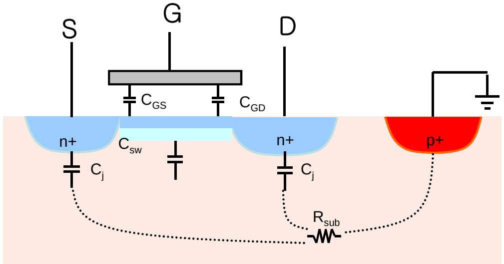
High Frequency Model of MOS

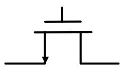
Off





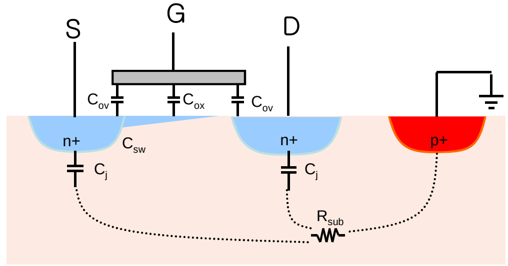
Triode
(Linear)

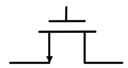


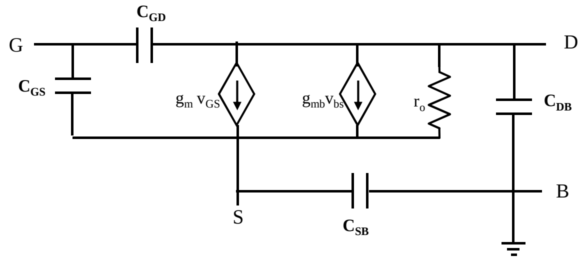


Small-Signal High Frequency Model

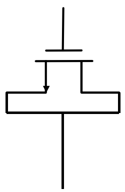
SAT







MOS Capacitance



C_{GS} = ?